Consumption Tax Competition Among Governments: Evidence from the United States

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Abstract

The paper contributes to a small but growing literature that estimates tax reaction functions of governments competing with other governments. We analyze consumption tax competition between US states, employing a panel of state-level data for 1977–2003. More specifically, we study the impact of a state's spatial characteristics—that is, its size, geographic position, and border length—on the strategic interaction with its neighbors. For this purpose, we calculate for each state an average effective consumption tax rate, which covers both sales and excise taxes. In addition, we pay attention to dynamics by including lagged dependent variables in the tax reaction function. We find overwhelming evidence for strategic interaction among state governments, but only partial support for the effect of spatial characteristics on tax setting. Tax competition seems to have lessened in the 1990s compared to the early 1980s.

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1 Introduction

US states have the legal power to set their own sales and excise taxes on goods and services. Consequently, tax rates and bases differ by state. In 2002, for example, Mississippi levied the highest sales tax rate (7 percent) of all US states. In contrast, Delaware, Montana, New Hampshire, and Oregon did not impose a sales tax at all. Similarly, excise tax rates and bases differ substantially. In 2002, New York levied a cigarette excise of US$ 1.50 per pack, whereas Kentucky imposed a rate of only US$ 0.03 per pack. All states levied an excise tax on cigarettes but 19 states did not charge excises on wine. Because commodity tax bases (i.e., the individuals purchasing products and services) are mobile, states will seek to steal tax base from one another by undercutting their neighbors' tax rates. This may unleash a tax competition game in which states repeatedly interact with each other. Our paper tries to empirically assess whether such strategic interaction exists between states.

We analyze consumption tax competition among US states, employing a panel data set of state-level consumption taxes (i.e., retail sales taxes on goods and services and excise taxes) for 1977–2003 covering 48 states.[1] To this end, we estimate tax reaction functions of state governments.[2] The slope of the tax reaction function indicates to what degree state government compete with each other.

Consumption tax competition has predominantly been studied from a theoretical point of view.[3] Recently, researchers' attention has shifted from theoretical to empirical work. Prior contributions are small in number and focus primarily on the United States.[4] All

[1] We do not cover sales and excise taxes at the local (county and municipal) level. Federal excises on transportation, communication, energy, alcohol, and tobacco are excluded as well.

[2] See Breuckner (2003) for an overview.

[3] Key contributions are those of Mintz and Tulkens (1986), Kanbur and Keen (1993), Lockwood (1993), Trandel (1994), Haufler (1996), Ohsawa (1999), Wang (1999), Nielsen (2001), Nielsen (2002), Ohsawa (2003, 2004), and Ohsawa and Koshizuka (2003). Wilson (1999) provides a more general overview of the tax competition literature.

[4] Studies on the United States are: Nelson (2002), Rork (2003), Luna (2004), Egger et al. (2005b), and Devereux et al. (2007). Evers et al. (2004) focus on diesel excise competition in Europe. Egger et al. (2005a) deals with tax competition among OECD countries.

studies employ the concept of a linear tax reaction function, which models the tax rate of the home jurisdiction as a function of that of other jurisdictions and various characteristics of the home jurisdiction. Estimated slopes of the tax reaction function vary substantially. Some studies find counterintuitive negative slopes for sales taxes (Rork, 2003), whereas others find values close to 0.9 for excises (Egger et al. 2005b). The latter suggests a substantial degree of interaction in tax setting, almost one for one. On average, across all studies, the reaction coefficient is 0.5.

Our paper contributes to the literature in three ways. First, our study employs an average *effective* tax rate (AETR) as measure of the tax burden.[5] The AETR on consumption (or implicit consumption tax) is defined as the ratio of the sum of sales tax and excise tax revenues to total consumption expenditures. Such a measure reflects the overall effective tax burden on consumption and should therefore be preferred over studies based on nominal sales tax rates only. Studies on commodity tax competition use either statutory sales tax rates (e.g., Rork, 2003; and Luna, 2004) or statutory (specific) excise tax rates (e.g., Nelson, 2002; Egger et al., 2005a; and Devereux et al., 2007).[6] The study by Egger et al. (2005b), using data for OECD countries, is a notable exception because they are the only ones analyzing AETRs. In the context of the United States, studies have not employed AETRs yet, reflecting the absence of official statistics on consumption at the state level. In this paper, we approximate state consumption on goods and services by non-durable retail sales by state—taken from the *Survey of Buying Power*—and an estimate for durable consumption.

A second contribution is that we explore the effect of a state's spatial characteristics—that is, its size, geographic position, and border length—on tax setting. Spatial effects are taken into account in the regression equation in two ways. We employ four different weight-

[5]See Mendoza et al. (1994) for a further exposition on the concept of AETRs.

[6]Devereux et al. (2007) correct the statutory (nominal) tax rates for inflation to arrive at a *real* tax rate. Note that the definition of an AETR implies that we do not have to worry about inflation correction.

ing schemes in characterizing the weighted average of AETRs of competing jurisdictions. We expect our estimate of the tax reaction coefficient (i.e., the slope of the tax reaction function) to be sensitive to the ex ante imposed spatial structure. In addition, we explicitly model (as separate variables in the equation) both time-variant and time-invariant spatial characteristics, which may affect the intercept of the tax reaction function.

Our third contribution is the explicit acknowledgement of the possibility of dynamics in our empirical tax competition model. If states react to each others' tax setting, the weighted average of competitors tax rates—which we use as an explanatory variable—is endogenous. The literature addresses this by employing an instrumental variable (IV) approach, typically also including state-specific fixed effects and time-specific fixed effects. We show that results obtained in this framework suffer from heteroscedasticity and serial correlation in the disturbances. Heteroscedasticity can be addressed by employing White-corrected standard errors, but the serial correlation poses a more serious challenge. It cannot be dealt with by including an instrumented lagged dependent variable in the "levels" specification (as proposed by Devereux et al., 2007) because of the correlation between the error term and fixed effects, on the one hand, and the lagged dependent variable on the other hand. To address this problem, we apply the Arellano-Bond (1991) Dynamic Panel Data (DPD) estimator to the tax reaction function written in "first differences."

The tax interaction coefficient in the levels specification (which does not correct for autocorrelation) is sensitive to the type of weighting scheme chosen. It yields a tax interaction coefficient in the range [0.57, 0.93], where the upper bound is obtained if competitors tax rates are weighted by distance and the lower bound results if population density weights are employed. By applying the DPD estimator, we find a tax reaction coefficient in the range [0.39, 0.48], which is much lower than the one estimated in levels. In both static and dynamic cases, strategic interaction seem to have lessened in the 1990s as compared to the early 1980s.

The paper is organized as follows. Section 2 provides a theoretical background to consumption tax competition. Section 3 sets out the methodological framework and discusses identification issues. Section 4 presents data on tax rate changes. Section 5 discusses the empirical results and performs a simple sensitivity analysis. Finally, Section 6 concludes.

2 Hypotheses

Our analysis builds on the theoretical tax competition literature, in which the strategic interaction among governments in tax setting is analyzed. The classic reference in the analysis of "origin-based" commodity tax competition is Kanbur and Keen (1993), who employ a simple cross-border shopping model, featuring two jurisdictions of fixed areal size. Kanbur and Keen consider a uniformly distributed population, which differs in size across jurisdictions. Households buy one unit of a commodity, which has a fixed producer price (assumed to be the same in both jurisdictions). A commodity's retail price in jurisdiction i consists of the sum of a specific consumption tax, τ_i, and the producer price. The representative household faces fixed transaction costs per unit of traveled distance if it purchases goods across the border. No travel costs are incurred if the consumer purchases goods locally. It follows that the consumer's decision to cross-border shop depends on a comparison between the transactions costs incurred in purchasing the goods in the other jurisdiction and the consumption taxes saved in doing so.

Both governments are assumed to set their consumption tax rates to maximize revenue, while taking as given the tax rate set by the other jurisdiction. This yields a tax reaction function of the general form: $\tau_i = f(\tau_j; \mathbf{V}_i)$, where $\mathbf{V}_i$ is a vector of characteristics of state i (e.g., state size) and f is a linear function (with $f' > 0$).[7] The two tax reaction functions can be solved to yield closed-form solutions for the optimal (Nash) tax rates. Equilibrium

[7] In fact, Kanbur and Keen (1993) show that the tax reaction functions are piecewise linear.

tax rates are shown to be below the social optimum, reflecting the effect of tax competition, and to be asymmetric (see below).

Ohsawa (1999) extends Kanbur and Keen's model to a multi-jurisdictional setting in which countries differ in areal size and consumers are uniformly distributed across markets.[8] He verifies the robustness of Kanbur and Keen's results to a larger number of jurisdictions. In turn, Ohsawa and Koshizuka (2003) investigate commodity tax competition between two jurisdictions in a two-dimensional setting, that is, including jurisdictional size and jurisdictional shape (e.g., border curvature and border length). In addition to showing that spatial characteristics matter, Ohsawa and Koshizuka (2003) demonstrate that the results obtained by Kanbur and Keen (1993) and Ohsawa (1999) are still valid. The above mentioned papers lead to the following three hypotheses, which we will employ in our empirical analysis.[9]

Strategic interaction in tax rate setting results in upward-sloping tax reaction functions (Hypothesis 1). The slope of the reaction function should be smaller than one to ensure the existence of a Nash equilibrium in tax rates. Obviously, the "knife-edge" case of a zero slope is of little practical interest because it implies that interaction between (local) governments is absent.

Hypothesis 1 (Kanbur and Keen, 1993) *A state's consumption tax rate is positively related to that of its neighbors.*

State (or jurisdictional) size plays a key role in consumption tax rate setting. Small jurisdictions have a smaller intercept of the tax reaction function than larger jurisdictions [Hypothesis 2(a)]. By undercutting, a small jurisdiction attracts cross-border shoppers (and thus generates extra revenue at a given tax rate), which exceeds the revenue loss

[8] In Ohsawa's model population density is constant across countries, whereas in Kanbur and Keen's world countries differ in population density.

[9] In view of the well developed existing theoretical frameworks, we have chosen not to develop our own analytical model.

from a lower tax rate applied to resident consumers. For a large jurisdiction, however, the revenue loss on the domestic base exceeds the revenue gain from cross-border shoppers. Ohsawa (1999) hypothesizes that the intercept of the tax reaction function of the home state rises with the size of the neighboring jurisdictions [Hypothesis 2(b)]. Kanbur and Keen (1993) and Nielsen (2001) show that this relationship is not clear-cut; undercutting the tax rate of the neighboring jurisdiction may be an attractive strategy for a small jurisdiction.

Hypothesis 2 (Kanbur and Keen, 1993; Ohsawa, 1999) *(a) Small jurisdictions tend to set lower equilibrium consumption tax rates than large jurisdictions [Kanbur and Keen, 1993]; and (b) The consumption tax rate of the home jurisdiction is strictly increasing in the jurisdictional size of its competitors [Ohsawa, 1999].*

Spatial characteristics of jurisdictions affect tax setting as is demonstrated by Ohsawa and Koshizuka (2003). Peripheral jurisdictions—of which (part of) their border is not exposed to competitive pressure from other states—set higher tax rates [Hypothesis 3(a)]. For example, Florida features a large unexposed border on the Atlantic Ocean and the Mexican gulf. For a given jurisdiction size, a more curved border or an increase in border length means a larger area exposed to cross-border shopping and the resulting competitive pressure. Consequently, exposed jurisdictions set lower tax rates [Hypothesis 3(b-c)].

Hypothesis 3 (Ohsawa and Koshizuka, 2003) *(a) For equally sized jurisdictions, consumption tax rates in peripheral jurisdictions are significantly higher than those in jurisdictions situated in the center of a federal country; (b) The consumption tax rate of a jurisdiction decreases if its border becomes more curved; and (c) The consumption tax rate of a jurisdiction decreases if its border length increases.*

3 Methodology

This section estimates tax reaction functions, which are specified in reduced form. To measure empirically strategic interaction among local governments, we need to address the issue of identification. In other words, do our results point to strategic interaction or is there some other cause (e.g., common shocks to a state's tax policy)? After a brief discussion of identification, this section describes the econometric specification of the tax reaction function, presents various weighting matrices, and discusses some econometric issues.

3.1 Identification in the Endogenous Interactions Model

Manski (1993) shows that the parameters in models of social/spatial interaction, the class to which tax competition belongs, are only identified under some strict assumptions. He defines three types of interaction: (i) contextual effects (related to exogenous characteristics of the group); (ii) endogenous effects (interaction between the units in the group); and (iii) correlated effects (characteristics that the units have in common, making them behave similarly). The challenge is to disentangle these three effects econometrically in a single equation.

To formally illustrate this, consider the following general cross-sectional model for a given time period:

$$Y_i = \alpha + \delta \mathrm{E}(Y_i|\mathbf{Z}_i) + \mathbf{X}_i'\beta + \mathrm{E}(\mathbf{X}_i|\mathbf{Z}_i)'\kappa + u_i, \qquad i = 1, ..., N, \tag{1}$$

where Y_i is the dependent variable (in our case the tax rate), $\mathbf{Z}_i$ is a vector of exogenous characteristics of the group (where boldface characters denote vectors), $\mathbf{X}_i$ are the observed characteristics of the units, E is the expectations operator, and N denotes the number of cross-sectional units. The parameters to be estimated are α, δ, β, and κ. The unobserved characteristics of individuals are included in u_i and are assumed to be correlated across the individuals in the group, that is, $\mathrm{E}(u|\mathbf{X}_i, \mathbf{Z}_i) = \mathbf{Z}_i'\eta$. This implies that the expected value of Y_i given the observed variables $\mathbf{X}_i$ and $\mathbf{Z}_i$ is given by:

$$\mathrm{E}(Y_i|\mathbf{X}_i, \mathbf{Z}_i) = \alpha + \delta \mathrm{E}(Y_i|\mathbf{X}_i) + \mathbf{X}_i'\beta + \mathrm{E}(\mathbf{X}_i|\mathbf{Z}_i)'\kappa + \mathbf{Z}_i'\eta. \tag{2}$$

In this equation, the endogenous effect is measured by the parameter δ, the contextual effect by κ, and the correlated effect by η. The reduced form of this model:

$$\mathrm{E}(Y_i|\mathbf{X}_i, \mathbf{Z}_i) = \alpha/(1-\delta) + \mathrm{E}(\mathbf{X}_i|\mathbf{Z}_i)'(\kappa+\beta)/(1-\delta) + \mathbf{Z}_i'\eta/(1-\delta), \qquad \delta \neq 1, \tag{3}$$

shows that the different social effects cannot be identified separately without imposing further restrictions.

As a first step in solving the specified identification problem, we can consider some of the practical restrictions imposed by the tax competition literature.[10] In general, the literature ignores the interaction effect between the observed group characteristics and the observed individual characteristics and thus assumes implicitly that $\kappa = 0$. This leaves use with the identification of the endogenous effect (δ) and the correlated effect (η), which is infeasible because both the conditional mean, $\mathrm{E}(Y_i|\mathbf{X}_i)$, and the exogenous group characteristics, $\mathbf{Z}_i'$ are constant over the cross-sectional units. The spatial econometrics literature address this issue by replacing $\mathrm{E}(Y_i|\mathbf{X}_i)$ with $\mathbf{W}Y_i$, where $\mathbf{W}$ is a $N \times N$ matrix of exogenously given spatial weights; $\mathbf{W}Y_i$ is thus a weighted average of the dependent variable in other (neighboring) jurisdictions. The identification problem is solved because the weighted average of neighbors introduces some cross-sectional variation in $\mathbf{W}Y_i$, as not all jurisdictions in the sample are treated identically, while $\mathbf{Z}_i$ remains constant.

[10]As Revelli (2005) points out there is also a second identification issue that plagues the empirical tax competition literature more generally. Based on a reduced-form equation such as (3), we are not able to discriminate between alternative theories of local government interaction (e.g., tax competition, yardstick competition, and spillovers of expenditures). We will not address this in the paper because this requires estimating a structural model.

3.2 Econometric Specification

The econometric specification of the theoretical tax reaction function explicitly takes into account the spatial pattern of tax competition. We employ a panel data set so that we can control for unobserved heterogeneity and study the dynamics of tax competition.

Tax Reaction Function

The AETR of state $i = 1, ..., N$ at time $t = 1, ..., T$ is denoted by $\bar{\tau}_{it}$, where N denotes the number of states and T represents the number of time periods. Now using the two assumptions introduced in the previous subsection, that is, assuming $\kappa = 0$ and replacing the conditional mean with the weighted average of the dependent variable in other (neighboring) jurisdictions, the tax reaction function of state i can be written as:

$$\bar{\tau}_{it} = \alpha_i + \eta_t + \delta \mathbf{W}_k \bar{\tau}_{it} + \mathbf{Q}'_{it}\gamma + \mathbf{X}'_{it}\beta + \varepsilon_{it}, \qquad (4)$$

where α_i is a state-specific fixed effect, η_t denotes the year-specific fixed effect, δ is the slope parameter, $\mathbf{Q}'_{it}$ and $\mathbf{X}'_{it}$ denote vectors of variables representing spatial and demographic characteristics of states and various control variables, respectively, with γ's and β's as parameters.[11] An error term, ε_{it}, completes the function. The tax rate of state i is a function of tax setting by its competitors, represented by the *spatial lag* term, $\mathbf{W}_k \bar{\tau}_{it}$, where $\mathbf{W}_k$ is a $N \times N$ matrix of spatial weights (see below). Because the AETR is by definition in the range $[0, 1]$, and thus a bounded outcome score, we take a logistic transformation $\bar{\tau}_{it} \equiv \ln(\tau_{it}/(1 - \tau_{it}))$, where τ_{it} is the AETR.[12] The logistic transformation is applied to the AETR variable on both sides of equation (4).

Based on Hypothesis 1, we expect positively sloped reaction functions, that is, $0 < \delta < 1$. To test Hypothesis 2(a) we include the population size of state i and expect

[11] Notice that the correlated effect from the social interactions model discussed in the previous section implies a fixed time effect in a panel data model, which is measured by η.

[12] The logistic transformation was originally suggested by Johnson (1949) to analyze bounded outcomes (e.g., [0,1] scores).

$\gamma_1 > 0$. Given Hypothesis 2(b), we expect the weighted population size of neighboring states to yield $\gamma_2 > 0$. Sea-bordered states—for which the dummy variable takes on the value one—are expected to set higher tax rates, that is, $\gamma_3 < 0$ [Hypothesis 3(a)]. Border curvature—defined as the ratio of border length and state size—depresses tax rates and thus $\gamma_4 < 0$ [Hypothesis 3(b)]. Border exposure, which is measured by the population density along the border region of both states i and j, has a depressing effect on tax rates (i.e., $\gamma_5 < 0$).

Our specification includes year-specific fixed effects and state-specific fixed effects. We include time effects to capture shocks that affect all states simultaneously, for example, a rise in the world oil price. The time effect also picks up changes in federal excise taxes, which we have not explicitly modeled.[13] State-specific fixed effects—which are time invariant—are incorporated to control for unobserved heterogeneity across states as well as historical differences. Intuitively, some states (e.g., Delaware, Montana, New Hampshire, and Oregon) oppose any sales taxation.

Weight Matrices

The weighting matrix reflects the importance of other states in influencing tax setting behavior of a particular state. The literature does not give much formal guidance on the choice of appropriate weight matrix.[14] Most often (fixed) geographic criteria are used, which yield purely exogenous weights. We apply four different specifications of weight matrices. The first matrix is constructed using the contiguity of states, that is, whether

[13] See Besley and Rosen (1998) and Devereux et al. (2007) for a empirical model incorporating both horizontal competition (i.e., between states) and vertical competition (i.e., between states and the federal level).

[14] Defining a weighting matrix is a standard practice in the literature not only for identification purposes (see Section 3.1) but also to reduce the large number of parameters that otherwise need to be estimated. The trivial weighting scheme of giving each state a uniform weight is not considered because it does capture any state characteristics. Moreover, we will not be able to incorporate time fixed effects while using a weighted average of *all* other states' tax rates.

they share a common border. The elements of the *neighboring states* matrix, $\mathbf{W}_C$, are:

$$w_{ij} \equiv \begin{cases} b_{ij}/\sum_{j=1}^{N} b_{ij} > 0 & \text{for } i \neq j \\ 0 & \text{for } i = j, \end{cases} \tag{5}$$

where b_{ij} is a border dummy which equals one when states i and $j = 1, ..., N$ share a common border and zero otherwise. Diagonal elements are by definition zero. Because rows are standardized (i.e., they add up to unity), the spatial lag represents a weighted average of tax rates. The second matrix is constructed using the inverse of the squared distance between two states to reflect a gravity type of approach. In contrast to the previous measure, the distance scheme captures tax competition among *all* states. The elements of the *distance matrix*, $\mathbf{W}_D$, can be characterized by:

$$w_{ij} \equiv \begin{cases} \frac{1}{d_{ij}^2}/\sum_{j=1}^{N} \frac{1}{d_{ij}^2} > 0 & \text{for } i \neq j \\ 0 & \text{for } i = j, \end{cases} \tag{6}$$

where d_{ij} reflects the geographical distance between the largest cities of states i and j, which is computed as the great circle distance given latitude and longitude.[15] States located far away from state i have a smaller impact upon its tax setting. Squaring the distance introduces a non-linearity; it increases the weight assigned to states located close to state i more than proportionally.

Both weighting matrices treat neighboring states with long borders—and thus more opportunities for cross-border shopping—in the same manner as states with short borders. Therefore, we also experiment with a third weighting scheme, which takes into account the length of the border between states i and j. The typical element of the *border length* matrix, $\mathbf{W}_B$, is:

$$w_{ij} \equiv \begin{cases} l_{ij}/\sum_{j=1}^{N} l_{ij} > 0 & \text{for } i \neq j \\ 0 & \text{for } i = j, \end{cases} \tag{7}$$

[15] Note that the largest city is not always situated in the center of the state. All possible alternative reference points, however, are equally disputable.

where l is the length (in miles) of the common border between states i and j. States with long borders, however, are not necessarily those featuring the largest number of cross-border shoppers. The incidence of cross-border shopping also depends on the population density along the border, which the final weighting scheme intends to capture. We calculate population density along the border as $s_{ij} \equiv P_{ij} + P_{ji}$, where P_{ij} is the population in all counties in state i adjacent to the common border of states i and j and P_{ji} denotes the population in all counties in state j adjacent to the common border of states i and j. The elements of the *population density* matrix, $\mathbf{W}_P$, are:

$$w_{ij} \equiv \begin{cases} s_{ij}/\sum_{j=1}^{N} s_{ij} > 0 & \text{for } i \neq j \\ 0 & \text{for } i = j. \end{cases} \tag{8}$$

We take population data at the country level for the year 2000 and assume that the weights remain constant over time.

Control Variables

The control variables can be classified into three broad categories: fiscal, political, and business cycle variables. The first category measures the effect of differences in fiscal policies across states. Two measures are used. The first is per capita public expenditure. Intuitively, as public expenditure rises, the state needs more revenue to balance its budget, providing an incentive to raise consumption tax rates.[16] Second, we use the lagged tax structure, which is defined as the ratio of direct tax revenue to indirect tax revenue. States with a higher ratio are expected to levy lower consumption taxes.

In keeping with Egger et al. (2005b) and Devereux et al. (2007), we include a variable representing a state's political orientation, which gets the value one in a year the governor

[16]The majority of states are required to balance their budget at the end of the fiscal year (28 in our sample) and some (seven in our sample) require a balanced budget over a two-year cycle. In addition, 36 states have debt restrictions of which 14 require a popular vote to issue any debt. See Table 3 of Poterba and Rueben (2001).

of a state is a Democrat and a zero otherwise. We hypothesize that Republican states prefer a smaller size of the public sector—and therefore are less likely to set high tax rates—than Democratic states (Reed, 2006). The unemployment rate is used to measure the impact of the business cycle on tax setting behavior of governments. It picks up two opposing effects. On the one hand, in an economic downturn state governments are less inclined to raise tax rates. On the other hand, the unemployment rate captures the effect of automatic stabilizers. A higher unemployment rate leads to more social security outlays and therefore yields an upward pressure on the tax rate. It is not a priori clear which force dominates.

Econometric Issues

Equation (4) shows that the consumption tax rates of competitors enter contemporaneously (i.e., $\bar{\tau}_i$ depends on $\bar{\tau}_j$ in the same time period), implying that we have to control for endogeneity. In that case, ordinary least squares estimation will be inconsistent, reflecting correlation between $\bar{\tau}_{it}$ and ε_{it}. We therefore resort to the IV approach, which yields consistent estimates even in the case of spatial error dependence. Following Kelejian and Prucha (1998), a mix of explanatory variables and weighted explanatory variables is used as instruments. More specifically, the weighted AETR is instrumented with the weighted unemployment rate and the weighted per capita public expenditure. The remaining variables are predetermined, lagged one period, and therefore also included in the instrument matrix.

3.3 Dynamics

Typically, dynamics are neglected in the estimation of tax reaction functions. A notable exception is Devereux et al. (2007), who deal with serial correlation by including a lagged dependent variable in their model. Because the lagged dependent variable correlates with the state fixed effect, they instrument it by including the second lag of the dependent variable. This instrument, however, still correlates with the error term (including the fixed effects) and thus invalidates the results. An ideal instrument would have been the state deficit-to-GDP ratio if it were not subject to legal and political restrictions (see footnote 16). We cannot think of any other candidate instruments and therefore adopt an alternative approach.

We include a lagged endogenous variable in the tax reaction function of equation (4):

$$\bar{\tau}_{it} = \alpha_i + \lambda\bar{\tau}_{i,t-1} + \delta\mathbf{W}_k\bar{\tau}_{it} + \gamma'\mathbf{Q}_{it} + \beta'\mathbf{X}_{it} + \varepsilon_{it}, \tag{9}$$

where λ is the coefficient of the lagged dependent variable, which capture dynamics. Subsequently, we use the Arellano-Bond (1991) DPD estimator, which is a General Method of Moments (GMM) estimator correcting for endogeneity by including lags of the dependent and explanatory variables.[17] The model is first differenced, implying that any (unobserved) state fixed effects as well as (observed) time-invariant variables are excluded. By applying the first differencing operation, we obtain:

$$\tilde{\bar{\tau}}_{it} = \lambda\tilde{\bar{\tau}}_{i,t-1} + \delta\mathbf{W}_k\tilde{\bar{\tau}}_{it} + \tilde{\mathbf{Q}}_{it}'\gamma + \tilde{\mathbf{X}}_{it}'\beta + \tilde{\varepsilon}_{it}, \tag{10}$$

where $\tilde{r}_{it} \equiv r_{it} - r_{i,t-1}$ for $r \in \{\bar{\tau}, \mathbf{Q}, \mathbf{X}, \varepsilon\}$. It is important to recognize that the coefficients λ, δ, γ, and β are still identified in the first differenced model and have the same interpretation as in the levels model. When estimating this model, the use of the DPD solves the endogeneity problem by instrumenting both the time-lag of the dependent variable and the weighted (neighboring) states tax rates. For instrumenting the time-lag of the dependent variable, we use the dynamic instruments suggested by Arellano and Bond (1991). As instruments for the weighted neighboring states tax rates, we choose per capita public expenditure and the unemployment rate (appropriately weighted by the respective

[17]See Baltagi (2005, Section 8.2) for details.

$\mathbf{W}_k$ matrix). It is important to recognize that the GMM method is robust against the distribution of the dependent variable.

Finally, the proposed instruments used in the GMM estimator must be valid, meaning that they are independent of unobserved heterogeneity and the error term. When the number of instruments is greater than the number of included endogenous variables, the validity of the selected instruments can be tested via an overidentifying restrictions test. We employ a Sargan test.[18] Unless reported otherwise, the Sargan overidentification test outcomes indicate that our instruments are valid (see Tables 3–5 below).

4 Data

Our data set covers 48 states over the period 1977–2002. Table A.1 in Appendix A presents the data definitions and sources. We do not include Alaska and Hawaii in our panel because these two states do not share borders with any other states in the United States. In addition, the District of Columbia (DC) is excluded, because of its special characteristics. DC is extremely small in size (68.3 square miles) and is mainly a working district.[19]

4.1 Estimating Average Effective Tax Rates

AETRs are defined as the ratio of consumption tax revenue to (before-tax) consumption expenditures. Statistics on consumption expenditures by state are not available. Following Ostergaard et al. (2002), we approximate private nondurable consumption expenditures at the state level by state-level data on retail sales of nondurable goods, which are reported in the *Survey of Buying Power* (published in *Sales and Marketing Management*). We estimate

[18]The null hypothesis of the Sargan test is that the overidentifying restrictions are valid. The Sargan statistic is $\chi^2_{(n-k)}$ distributed, where n denotes the rank of the instrument matrix and k is the number of estimated coefficients.

[19]People living in DC spend their money in the surrounding states (i.e., Maryland and Virginia), where the majority of shopping malls are located.

state-level private spending on durable consumption goods.[20] We prefer using AETRs instead of *statutory* sales tax rates as indicator of the tax burden for three compelling reasons. First and foremost, consumers base their consumption decision upon the *total* consumption tax burden on goods. More specifically, the consumer compares the difference in tax burdens between the respective neighboring states and that of the own state with the transaction costs of purchasing in another state.[21] Suppose a consumer purchases one unit of a consumption good subject to both an *ad valorem* sales tax, τ_s (measured in percent of value), and a *specific* excise tax, τ_e (measured in US dollars per unit). Given that the sales tax on goods and services is paid on an excise-tax inclusive base, we get tax payments (excluding any federal excises) of:

$$T \equiv (p + \tau_e)(1 + \tau_s) - p = \tau_e + p\tau_s + \tau_e\tau_s, \tag{11}$$

where p denotes the sales price exclusive of tax. On key commodities—that is, beer, cigarettes, distilled spirits, gasoline, and wine—the consumer pays *both* excises (the first term on the right-hand side of (11)) and sales tax (the second term), which none of the previous studies takes into account. Note that the commodities which are most likely to be featuring in cross-borders purchases are typically subject to excises. The share of excises in total consumption tax revenue in the year 2002 amounts on the order of 40 percent. To study tax competition, one can thus not solely focus on one tax category. Notice that equation (11) also shows that the consumer pays "tax-on-tax" (the last term), which is not picked up by measures based on the sum of statutory tax rates. Although small in many cases, the *tax interaction effect* makes a difference for items such as distilled spirits. For

[20]We assume a fixed share of durable private consumption goods. Aggregate US durable private consumption is approximated by the difference between aggregate US private consumption expenditures and aggregate US retail sales (both measured at market prices). Note that this also includes nondurable private consumption expenditures that are not included in retail sales (e.g., travel expenditures). We focus on private consumption only because we do not have state-level data on goods and services purchased by the government. The latter amounts to roughly 5 percent of total goods and services consumption across states.

[21]Federal excises do not play a role in this comparison, but county level sales taxes on goods and services could be important. Unfortunately, we do not have data on the latter.

example, in the state New Mexico the sales tax rate amounts to 5 percent and the excise on distilled spirits is US$ 6.06 per gallon, yielding a tax-interaction effect of US$ 0.30 per gallon. Second, AETRs include all relevant components of a tax law (such as exemptions) and take into account the degree of tax enforcement, allowing us to compare states with very distinct tax structures and tax enforcement cultures. For example, Montana does not have a sales tax but generates a significant amount of consumption tax revenue (23.6 percent of total revenue in 2001), reflecting excise tax revenue. Third, AETRs change annually, whereas statutory tax rates change less frequently.

4.2 Descriptive Statistics on Tax Rate Setting

The top panel of Table 1 presents statistics describing the number of rate changes across states and over time. Not surprisingly, state governments tinker the most with gasoline excises. Excises on cigarettes feature the second highest mean number of changes. The normalized standard deviation[22] of rate changes for these two products are the smallest, suggesting that the majority of states cluster around the mean and thus compete heavily. Nebraska adjusts its gasoline excises a record number of times. New York is the leader in changing its beer, wine, and distilled spirits excises. States change their statutory sales tax rates on average two times during a time span of 26 years, which is smaller than the average for excises (three changes). Some states (e.g., Maryland) do not adjust their sales tax rates at all, whereas New Mexico changes its sales tax rate about six times. Not surprisingly, tax rate increases are much more common than tax rate reductions. More specifically, our data set reveals that only 17 of 96 (18 percent) changes in sales taxes pertain to tax rate reductions. We find roughly similar evidence for gasoline excises, for which we observe tax rate reductions in 16 percent of the cases.

[22]The standard deviation of the tax rate of a particular state is divided by the mean of the tax rate of that state (known as the coefficient of variation) to facilitate a unit free statistic that can be compared across states and tax categories.

The center panel of Table 1 shows the mean size of tax changes (in absolute terms). The overall average change in the sales tax rate is very small (on the order of 0.07 percentage points). Once we exclude all observations where tax rates do not change, the average sales tax change is much higher; it amounts to 0.88 percentage points, which is roughly 20 percent of the overall average sales tax rate. Gasoline excises change more frequently and are of smaller size (15 percent of the average rate). The absolute change in the AETR is much larger than that of the sales tax, reflecting the contribution of revenue from excises.

The bottom panel shows that the average statutory sales tax rate amounts to 5.2 percent in 2002. It thereby exceeds the AETR (4.1 percent), owing to collection losses on sales taxes (reflecting tax evasion, exemptions and the like) exceeding the additional revenue generated by excises. Average excise tax rates per gallon vary between US$ 0.19 (gasoline) and US$ 3.55 (distilled spirits). Florida sets the highest excises on distilled spirits and wine (US$ 2.25).

Table 2 shows that the average statutory sales tax across state groupings varies between 3.5 percent and 5.3 percent. Middle Atlantic States (New Jersey, New York, and Pennsylvania) have the highest statutory sales tax. The overall average statutory sales tax rate is slightly higher than the AETR, which is not necessarily true for particular state groups. For example, the Pacific Coast States (California, Oregon, and Washington) appear to have a higher AETR, possibly reflecting substantial excise revenue collections. In addition, AETRs are not necessarily more variable than statutory tax rates. In the aggregate, the variability of AETRs is similar to that of statutory sales tax rates. By state grouping the two measures differ, but there is no systematic pattern.

5 Empirical Results

Table 3 shows estimation outcomes of the static tax reaction function (see equation (4)), using the four different weight matrices introduced above. The tax reaction coefficient can be interpreted as a 'corrected tax elasticity,' reflecting the logarithmic transformation of the AETR taken on both sides of the equation. The corrected elasticity is defined as $\frac{\partial \bar{\tau}_{it}}{\partial \mathbf{W}_k \bar{\tau}_{jt}} = \frac{\partial \hat{\tau}_{it}}{\partial \hat{\tau}_{jt}} \frac{\hat{\tau}_{jt}}{\hat{\tau}_{it}} = \delta$, where $\bar{\tau}_{it} \equiv \ln(\hat{\tau}_{it})$ and $\hat{\tau}_{it} \equiv \frac{\tau_{it}}{1-\tau_{it}}$.[23] For all four weighting matrices, we find a positive slope of the tax reaction function in line with Hypothesis 1. All slope parameters are smaller than one, which ensures the existence of a Nash equilibrium in tax rates. However, the size of the slope parameter varies with the weight matrix used. The distance weight matrix, $\mathbf{W}_D$, produces the highest slope coefficient (0.93), whereas the population density weight matrix, $\mathbf{W}_P$, is lowest (0.57). In addition, state size enters the model with a positive sign and the weighted size of neighboring states with a negative sign.[24] The first outcome is in accordance with Hypothesis 2(a), but the second outcome does not corroborate Hypothesis 2(b), although this result is foreshadowed by Nielsen (2001). The significance of the tax structure and per capita public expenditure, both lagged one period, complete the model. Both show the expected sign. Lagged unemployment and political orientation did not prove to be significant.

To investigate Hypothesis 3, we include several spatial characteristics in the tax reaction function with the population density weight matrix.[25] We drop state fixed-effects from the model to avoid multicollinearity between time-invariant spatial characteristics and fixed effects. Table 4 reports the outcomes. A direct consequence of replacing state fixed effects by spatial characteristics is a reduction in the adjusted R^2. Apparently, state fixed effects

[23] Note tat $\gamma = \frac{1}{\hat{\tau}_{it}} \frac{\partial \hat{\tau}_{it}}{\partial \mathbf{Q}_i}$ and $\beta = \frac{1}{\hat{\tau}_{it}} \frac{\partial \hat{\tau}_{it}}{\partial \mathbf{Z}_i}$ are interpreted as semi-elasticities.

[24] We experimented with different measures of state size (i.e., surface area and labor force), which did not influence our conclusions.

[25] The population density weight matrix has the highest intuitive appeal. Experiments with the other three weights, however, yield the same qualitative conclusions.

explain a larger share of the variation than the respective spatial variable that is included. Hypothesis 3 seems to hold. All spatial variables, which enter the tax reaction function separately, have a significant impact on the tax rate. However, border curvature does not have the a priori expected negative sign. Border exposure, that is, the density of people living in counties near the state border, has a direct negative impact on the tax rate.

The inclusion of spatial characteristics does not affect the slope of the tax reaction function, which stays close to 0.5. However, the parameters of state size and weighted size of neighboring states change sign, and the effect of lagged per capita public expenditure becomes much larger. In contrast to the previous table, lagged unemployment and political orientation play a role. These control variables do have the ex ante expected signs.

The static tax reaction function outcomes as presented in Tables 3 and 4 suffer from serial correlation, as can be seen from the Wooldridge (2002, pp. 282-83) serial correlation test. Therefore, Table 5 presents estimates of the dynamic tax reaction function [equations (9)–(10]. Here, we report the usual standard deviations instead of White diagonal standard deviations. The lagged endogenous variable is highly significant for all specifications of the weight matrix, with parameter estimates just above 0.5. Do our hypotheses still hold for the dynamic tax reaction function? The slopes of the tax reaction functions are significantly positive, but become less steep compared to the static model. Therefore, Hypothesis 1 still holds. The evidence for Hypothesis 2 is mixed. We do not find a significant effect of state size on the tax rate [Hypothesis 2(a)]. We do find, however, a significantly negative effect of the size of neighboring states [Hypothesis 2(b)]. Notice that, as mentioned before, theoretically the interpretation of the coefficients does not change after a first differencing operation has been applied. A disadvantage of the Arellano-Bond DPD estimator is that time-invariant variables cannot be included explicitly in the model. Therefore, we cannot formally address Hypothesis 3 in this framework.

To investigate whether tax competition has changed over time, we split the sample into two subperiods: 1977–1990 and 1991–2003. For all weighting matrices, we find that the slope parameter is much larger in the first subperiod as compared to the second subperiod. This is true for both the fixed effects and the dynamic model. To illustrate, we will focus on the population density weight matrix.[26] Turning to the fixed effects model first, we find that the slope parameter in the first subperiod is significant and exceeds unity (i.e., 1.03); it is thus much larger than the coefficient of 0.57 for the full sample. Furthermore, the slope parameter in the second subperiod is insignificant, suggesting a higher degree of strategic interaction between state governments in the first period. For the dynamic model during the first period, we find a significant slope parameter of 0.72, which again exceeds the (significant) value of 0.39 based on the complete sample. In the second subperiod, we find a significant slope parameter of 0.12, suggesting a larger degree of tax competition in the 1980s.

6 Conclusions

This paper measured tax competition between US states, using a panel data set of state-level consumption taxes (i.e., retail sales taxes on goods and services and excise taxes collected by state governments) for the period 1977–2003 covering 48 states. We estimate both static and dynamic tax reaction functions.

We found strong evidence for strategic interaction among US states, both in static and dynamic tax reaction functions. We observed a larger degree of strategic interaction during the 1980s than during the 1990s. In addition, spatial characteristics influence both the intercept and the slope of the tax reaction function. States near the oceans and Mexican Gulf set higher tax rates than inland states. Finally, a higher population density along the border region has a negative impact on consumption tax rates.

[26]The results for the other weighting matrices are available upon request from the authors.

In future work, we intend to apply the analysis to a broad set of (more heterogeneous) countries, including OECD and non-OECD countries. Further research should also address spatial econometric issues, because our dependent variable suffers from spatial correlation.

Table 1: Descriptive Statistics on Statutory and Average Effective Tax Rates, 1977–2002

	Statutory tax rates						AETR[a]
	Sales tax (In percent)	Excises (In US$ per unit)					(In percent)
		Beer (Per gallon)	Cigarettes (Per pack)	Distilled spirits (Per gallon)	Gasoline (Per gallon)	Wine (Per gallon)	
	Changes in tax rates across states and years						
Number of tax rate changes:							
Mean	2.18	1.38	3.38	2.10	6.46	1.93	–
Maximum	6	6	9	9	19	5	–
State(s) with maximum[b]	NM	NY	WA	NY, NM	NE	NY, MO	–
Coefficient of variation[c]	0.69	1.08	0.64	1.13	0.61	0.84	–
Absolute tax rate changes:							
Mean (including zeros)	0.066	0.003	0.016	0.068	0.006	0.012	0.190
Mean (excluding zeros)[d]	0.875	0.053	0.103	0.848	0.023	0.132	0.190
	Tax rates in 2002 across states						
Mean	5.19	0.22	0.52	3.55	0.19	0.65[e]	4.08
Maximum	7.00	0.77	1.50	6.50	0.28	2.25	9.93
State(s) with maximum[b]	MS	SC	NY	FL	RI	FL	WA
Coefficient of variation[c]	0.19	0.68	0.79	0.38	0.27	0.72	0.36
Number of states[f]	44	48	48	30	48	29	48

Sources: Office of Tax Policy Research, *World Tax Database*; and authors' own calculations.

[a] The AETR denotes the average effective consumption tax rate.

[b] The state labels are follows: Florida (FL), Mississippi (MS), Missouri (M0), Nebraska (NE), New Mexico (NM), New York (NY), Rhode Island (RI), South Carolina (SC), and Washington (WA).

[c] The coefficient of variation (defined as the standard deviation divided by the mean) measures the average variation of the tax rate.

[d] The sample sizes per tax category differ because of the elimination of the zeros.

[e] Data are for 2001.

[f] Alaska and Hawaii are excluded because these states do not share a common border with other US states. The numbers per tax category may differ because not all states have a sales tax (e.g., Delaware, Montana, New Hampshire, and Oregon) or excise tax.

Table 2: Statutory and Average Effective Tax Rates by Region, 1977–2002

Region[a]	Average statutory sales tax rate		AETR[b]	
	Average	Variation[c]	Average	Variation[c]
Middle Atlantic States	5.28	0.031	4.09	0.084
Midwestern States	4.57	0.149	3.30	0.092
New England States	4.64	0.078	3.74	0.124
Pacific Coast States	3.79	0.082	4.13	0.098
Rocky Mountain States	3.52	0.114	3.77	0.141
Southern States	4.22	0.106	4.45	0.105
Southwestern States	4.53	0.190	4.46	0.119
Average	4.36	0.107	4.06	0.109

Sources: Office of Tax Policy Research, *World Tax Database*; and authors' own calculations.

[a] The grouping of states is as follows: *Middle Atlantic States* (New Jersey, New York, and Pennsylvania), *Midwestern States* (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin), *New England States* (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont), *Pacific Coast States* (California, Oregon, and Washington), *Rocky Mountain States* (Colorado, Idaho, Montana, Nevada, Utah, and Wyoming), *Southern States* (Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia), and *Southwestern States* (Arizona, New Mexico, Oklahoma, and Texas). Alaska and Hawaii are excluded, yielding a total of 48 states.

[b] The AETR denotes the average effective consumption tax rate.

[c] The coefficient of variation (defined as the mean divided by the standard deviation) measures the average variation of the tax rate in the specific region.

Table 3: Static Model With Both State and Time Fixed Effects

Weighting matrix	Contiguity	Distance	Border length	Population
Weighted AETR	0.689***	0.927***	0.703***	0.572***
	(0.167)	(0.208)	(0.181)	(0.156)
State size	0.018***	0.011**	0.015***	0.013**
	(0.005)	(0.005)	(0.006)	(0.005)
Weighted state size of neighbors	-0.041***	-0.021	-0.023**	-0.018*
	(0.010)	(0.020)	(0.009)	(0.009)
Tax structure at $t-1$	-0.213***	-0.208***	-0.200***	-0.209***
	(0.025)	(0.024)	(0.025)	(0.024)
Per capita public expenditure at $t-1$	0.039***	0.036**	0.042**	0.041**
	(0.017)	(0.017)	(0.017)	(0.016)
Unemployment rate at $t-1$	-0.001	0.000	-0.001	0.000
	(0.004)	(0.004)	(0.004)	(0.004)
Political orientation	-0.002	0.002	0.001	0.004
	(0.007)	(0.006)	(0.007)	(0.007)
Adj. R^2	0.941	0.942	0.939	0.942
Observations	1,248	1,248	1,248	1,248
Sargan test	0.006	0.429	0.000	0.985
p-value	0.940	0.510	0.980	0.320
Wooldridge test	16.651	18.759	15.047	17.302
p-value	0.000	0.000	0.000	0.000
Instrument rank	81	81	81	81

Notes: ***, **, * denote significance at the 1, 5 or 10 percent level, respectively. White diagonal standard deviations are reported in parentheses below the parameter estimates. Period and cross-section fixed effects are included. The weighted AETR is instrumented with the weighted unemployment rate and the weighted per capita public expenditure. The remaining variables are assumed to be exogenous and therefore also included in the instrument matrix. Reported value for the Wooldridge test is the t-statistic.

Table 4: Static Model with Time Fixed Effects and Various Spatial Characteristics

Spatial characteristics	Sea bordered	Border curvature	Border length
Population weighted AETR	0.457***	0.457***	0.523***
	(0.108)	(0.107)	(0.127)
State size	-0.007***	-0.006***	-0.007***
	(0.002)	(0.002)	(0.002)
Weighted state size of neighbors	0.007**	0.005**	0.003
	(0.003)	(0.003)	(0.003)
Tax structure $t-1$	-0.346***	-0.340***	-0.343***
	(0.011)	(0.011)	(0.011)
Per capita public expenditure $t-1$	0.304***	0.339***	0.321***
	(0.026)	(0.028)	(0.028)
Unemployment rate $t-1$	0.031***	0.029***	0.030***
	(0.005)	(0.005)	(0.005)
Political orientation	0.044***	0.051***	0.05***
	(0.015)	(0.015)	(0.016)
Dummy sea bordered	0.078***	–	–
	(0.016)		
Border curvature	–	1.717***	–
		(0.420)	
Border length	–	–	-0.099***
			(0.028)
Exposure	-0.033**	-0.063***	-0.045***
	(0.014)	(0.017)	(0.014)
Adj. R^2	0.681	0.678	0.657
Observations	1,248	1,248	1,248
Sargan test	0.124	0.013	0.078
p-value	0.720	0.908	0.779
Wooldridge test	24.809	25.230	23.015
p-value	0.000	0.000	0.000
Instrument rank	36	36	36

Notes: ***, **, * denote significance at the 1, 5 or 10 percent level, respectively. White diagonal standard errors are reported in parentheses below the parameter estimates. Only year fixed effects are included. The weighted AETR is instrumented by the unemployment rate and per capita public expenditure (both weighted twice). The remaining variables are considered to be exogenous. Reported value for the Wooldridge test is the t-statistic.

Table 5: Dynamic Model Estimated Using Arellano-Bond

Weighting matrix	Contiguity	Distance	Border length	Population
Lagged AETR	0.554***	0.524***	0.515***	0.541***
	(0.026)	(0.024)	(0.032)	(0.029)
Weighted AETR	0.409***	0.483***	0.406***	0.394***
	(0.029)	(0.043)	(0.037)	(0.041)
State size	0.002	-0.001	0.002	-0.002
	(0.005)	(0.004)	(0.005)	(0.005)
Weighted state size of neighbors	-0.015*	-0.008	-0.015**	-0.011*
	(0.008)	(0.019)	(0.006)	(0.006)
Tax structure $t-1$	-0.062***	-0.065***	-0.058***	-0.062***
	(0.002)	(0.004)	(0.003)	(0.003)
Per capita public expenditure $t-1$	0.013***	0.013***	0.012***	0.012***
	(0.004)	(0.005)	(0.003)	(0.003)
Unemployment rate $t-1$	0.005***	0.005***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Political orientation	0.001	0.000	0.002	0.005
	(0.010)	(0.010)	(0.009)	(0.009)
Adj. R^2	0.547	0.555	0.537	0.538
Observations	1,200	1,200	1,200	1,200
Sargan test	41.479	41.131	39.225	39.899
p-value	0.406	0.465	0.505	0.475
Instrument rank	48	49	48	48

Notes: ***, **, * denote significance at the 1, 5 or 10 percent level, respectively. Standard errors are presented in parentheses below the parameter estimates. State fixed effects are included. The weighted AETR is instrumented by the unemployment rate and the per capita public expenditure weighted by the population density.

Appendix

Table A.1 sets out the variable definitions and data sources.

Total retail sales reflects *net* sales (gross sales minus refunds and allowances for returns) for all establishments primarily engaged in retail trade, plus eating and drinking establishments. Receipts from repairs and other services (by retailers) are also included, but retail sales by wholesalers and service establishments are not. Note that sales for some establishments (e.g., lumber yards, paint, glass, and wall-paper stores, and office supply stores) are also included, even if they sell more to businesses than to consumers.

Table A.1: Variable Definitions and Data Sources

Definition	Source	Internet location
Inputs for AETR		
Retail sales (in thousands of US$)	Survey of Buying Power, 1978–2004	www.salesandmarketing.com
Aggregate consumption (in thousands of US$)	IMF's International Financial Statistics	www.ifs.apdi.net/imf
Sales tax revenue (in thousands of US$)	World Tax Database	www.wtdb.org
Excise tax revenue (in thousands of US$)	World Tax Database	www.wtdb.org
Inputs for weighting schemes		
Distance between largest cities (in miles)	Darrell Kindred's web site	www.cs.cmu.edu/~dkindred/home.html
Border length (in miles)	Thomas J. Holmes's web site	www.econ.umn.edu/~holmes/data/borderdata.html
County population along border (number of individuals)	US Census Bureau	www.census.gov
Inputs for size and geographic variables		
Population (in millions)	Bureau of Economic Analysis	www.bea.gov
Geographic area (in square miles)	US Census Bureau	quickfacts.census.gov
Inputs for control variables		
Direct tax revenues (in thousands of US$)	World Tax Database	www.wtdb.org/index.html
Indirect tax revenues (in thousands of US$)	World Tax Database	www.wtdb.org/index.html
Public expenditure (in thousands of US$)	World Tax Database	www.wtdb.org/index.html
Party of the Governor (dummy)	Individual states	Web sites of individual states
Unemployment rate (in percent)	Bureau of Labor Statistics	www.bls.gov or www.economagic.com

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